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THE MEDICAL BIOLOGY OF BRAZILIAN CALLIPHORIDAE: MECHANISM FOR DISEASE TRANSMISSION

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There are about 22 reported species of calliphorids in Brazil. The habits, distribution, and life cycles of the majority of these flies are largely unknown. These facts are necessary to (1) identify the potentially important vectors; (2) determine in which places and under what conditions each species is likely to become a problem; (3) learn how to avoid fly build-up; and (4) implement effective control measures in the event fly build-up does occur.

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REPORT: THE MEDICAL BIOLOGY OF BRAZILIAN CALLIPHORIDAE: MECHANISM FOR DISEASE TRANSMISSION

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SUMMARY

Personnel and facilities in eleven widely distributed medical entomology laboratories in Brazil were evaluated in a feasibility study for a full-scale scientific investigation of fly-borne disease. The United States military experience elsewhere, and a vast body of scientific evidence have shown that high fly density and high enteric disease morbidity go hand-in-hand. In Brazil, synanthropic flies are abundant and active the year around as potential vectors of enteric pathogens and agents of myiasis. Breakdown of sanitation in military situations, e.g. inadequate disposal of human excrement and garbage, can produce explosive outbreaks of flies and enteric disease to hamper military operations.

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A full-scale study of the medical biology of Brazilian calliphorids, the house fly, and other synanthropic flies is feasible and strongly recommended. Five factors underscore the importance of such an investigation to the medical

mission of the military: (1) prevalence of enteric disease throughout the country; (2) abundance of synanthropic flies the year around; (3) absence of vital information on this medically important group of flies; (4) existence of suitable research facilities in Brazil; and (5) enthusiasm for the project by Brazilian medical entomologists.

PURPOSE

Site visits to major centers of medical entomology in Brazil were made to gain firsthand information on fly-borne diseases and the resources — human, scientific, and environmental — that could be marshalled to study and control the problem.

SCIENTIFIC MISSION

Previously, we studied the medical biology of Peruvian Calliphoridae during four NSF-sponsored expeditions to Peru. The results may be summarized briefly, as follows:

1. The first report of Cochliomyia hominivorax, the primary screwworm fly, in Peru, with descriptions of variations in male genitalia from different regions, and non-attraction of adult flies to Swormlure-2 which is generally attractive in Mexico and the U.S. (Baumgartner and Greenberg 1983);

2. The first report of Chrysomya albiceps and Chrysomya putoria in Peru, with calculations of their dispersal rate in South America, temperature and bait preferences, synanthropic indices, and documentation of the concomitant suppression of endemic Cochliomyia macellaria, probably by these species (Baumgartner and Greenberg 1984);

3. Isofemale rearings of 15 species, 12 for the first time, with descriptions of each larval instar, puparia and eggs, with data on developmental rates, and a key to known 3rd instar larvae of Peru (Greenberg and Szyska 1984);

4. The altitudinal (temperature) range, behavior and habits of 26 species, 5 reported for the first time from Peru. Included are: bait preferences of 20 species (many at four elevations); endophily of 14 species; synanthropic indices of 13 species (many at four elevations); and the diurnal activity curves of 9 species (some at several elevations) (Baumgartner and Greenberg 1985).

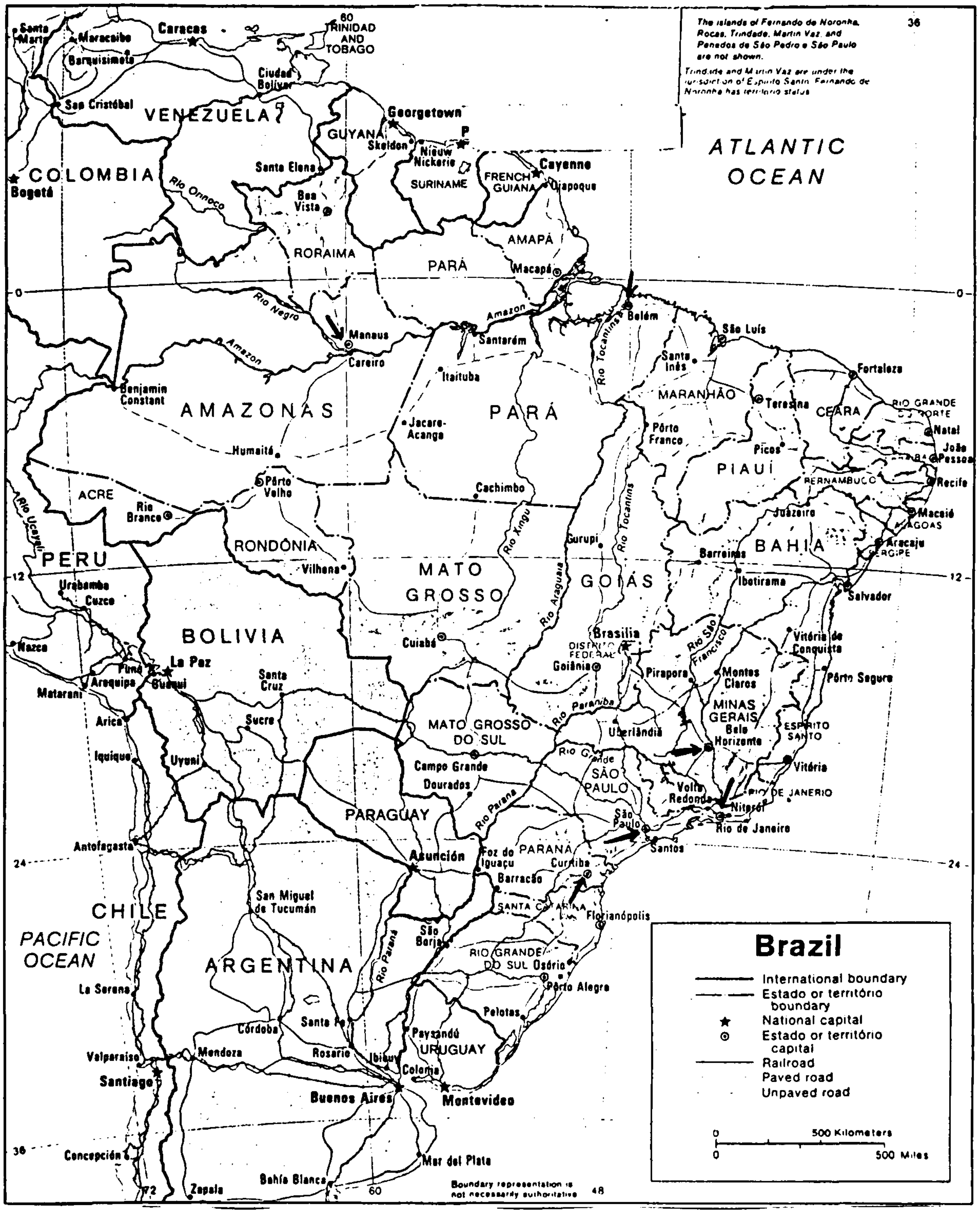
These studies, for the first time, systematize the medical biology and habits of the majority of Peruvian blow flies, and identify the potentially important vectors. With available keys (e.g. Dear 1985; Dear 1979; Mariluis 1981, 1982), these studies provide the detailed information required for a medical assessment of each species of calliphorid and the field conditions in which it is likely to become a problem.

Llewellyn and Dolev (1985) state that it is false to assume that a single approach to field medical support will suffice for any and all military operations. This applies with equal validity to the medical entomological problems troops are likely to encounter in various places. As conditions change from region to region, and from asynanthropic to eusynanthropic situations within a single region, the vectors and their relevant habits will also change. In a military operation in urbanized terrain (MOUT), protracted operations exacerbate health risks due to breakdown in sanitation and water systems, and uncontrolled increases in insect and rodent populations (Llewellyn and Dolev 1985). Inadequate disposal of human excrement and garbage will quickly produce huge populations of flies to contaminate food

with enteric pathogens. Under conditions where MOUT leads to high casualty rates and significant delays in casualty accession, wound myiasis may also become significant. Finally, the restoration of "life-line services" for sanitation, water, and food would have to include appropriate fly abatement measures for the health and morale of both the military and civilian populations.

Brazil has about eight times the area of Peru and occupies nearly half of South America. Despite its vast size, Brazil's calliphorid fauna appears to be less than that of Peru. This could be due to inadequate study or because the country is essentially tropical and sub-tropical. The average annual temperature at the Uruguayan border in the south is 17 to 19°C. This increases steadily from south to north, as the difference in temperature between the coldest and warmest month decreases. But even on the equator, in the Amazon Basin, the average temperature is not more than 27°C, with the highest recorded temperature of 36°C. The dry northeastern states have temperatures averaging 6°C higher. The Brazilian Highlands is an escarpment, 300 to 900 meters high, with a mean annual temperature of 18 to 21°C. The region is cooler than states to the north but warmer than Santa Catarina, São Paulo, etc. to the south. It has one of the largest populations in Brazil and its synanthropic fly fauna, as in most regions, has not been systematically studied.

There are few montane habitats in Brazil — the two highest peaks are about 3000 m high. This confines psychrophilic genera e.g. Sarconesia and Calliphora to the cooler parts of the country. While there are 4 or 5 species of Sarconesia in Peru, only the eurythermal S. chlorogaster seems to be present in Brazil, primarily in the south. Calliphora vicina, a cool weather holarctic eusynanthrope, is confined to southern Brazil; Calliphora lopesi



Map of Brazil. Arrows Indicate Places Visited.

appears to have its northernmost boundary in the central highlands in the state of Rio de Janeiro. Extensive field work is needed to fill in large gaps in current knowledge of blow fly distributions in this country. As in Peru, it would undoubtedly bring to light the presence of potential vectors and annoyers, previously unreported.

Table 1 is a list of calliphorids we collected in Peru. The starred ones are new records for Peru; those with a cross I also found in collections from Brazil. Table 2 lists calliphorids found in Brazil but not in Peru. Table 3 lists those which, to our knowledge, have not been reared and whose life cycles and developmental rates and stages are unknown, and/or whose vector potential justifies more study.

We include Cochliomyia hominivorax, the primary screwworm fly, because of its widespread involvement in human and animal myiasis in Brazil (and South America, generally). There are questions concerning variations in genitalia, karyotype, and behavior and the possible impact of these differences on myiasis. C. hominivorax myiasis of humans is reported from various parts of Brazil but it is most critical in the Amazon and in the savannah regions of Goiás and Mato Grosso. Pavan and his group at the University of Campinas are convinced that there may be as many as eight screwworm species, based on 16 karyotypes and 19 morphological characters (personal communication, 1985; also Azeredo-Espin 1982). Richardson et al. (1982a,b), working on behavior and karyotypes of Mexican populations, is also convinced he is looking at several distinct species. McKinnis (1981, 1983, also McKinnis et al. 1983) concludes, on much the same evidence, that C. hominivorax is a single polymorphic species; LaChance and his group support this concept (1982). I should point out that Brazilians are incurable splitters and hominivorax is grist for their mill. The important point, however, is that some of these populations do not

Table 1. Calliphoridae Collected in Central Peru

Chrysomyinae

1. Chloroprocta idioidea (R.-D.)†
2. Chrysomya albiceps albiceps (Wied.)
3. Chrysomya chloropyga putoria (Wied.)
4. Cochliomyia hominivorax (Coq.)
5. Cochliomyia macellaria (Fab.)
6. Compsomyiops boliviana (Mello)
7. Compsomyiops verena (Walk.)
8. Hemilucilia benoisti Seguy
9. Hemilucilia hermanlenti Mello*†
10. Hemilucilia melusina Dear
11. Hemilucilia segmentaria (Fab.)†
12. Hemilucilia semidiaphana (Rond.)
13. Hemilucilia townsendi Shan.
14. Paralucilia adespota Dear†
15. Paralucilia fulvinota (Bigot)†

Calliphorinae

16. Calliphora peruviana R.-D.
17. Phaenicia cuprina cuprina (Wied.)†
18. Phaenicia eximia (Wied.)*†
19. Phaenicia ibis (Shan.)
20. Phaenicia ochricornis (Wied.)*
21. Phaenicia purpurescens (Walk.)
22. Phaenicia sericata (Meig.)*†

Toxotarsinae

23. Sarconesia chlorogaster (Wied.)†
24. Sarconesia magellanica (LeGuillou)
25. Sarconesia splendida (Townsend)
26. Sarconesia versicolor Bigot*

*Species documented for the first time in Peru.
†Also in Brazilian collections.

Table 2. Brazilian Calliphorids not Collected in Peru

Calliphora vicina R.-D.
Calliphora lopesi Mello
Phaenicia japuhybensis Mello
Chloroprocta fuscanipennis (Macq.) (= *idioidea*?)
Chrysomya megacephala (Fab.)
Hemilucilia souzalopesi Mello
Paralucilia fulvicrura (R.-D.)
Kuschelomyia ambrosiana Lopes

Table 3. Calliphorids Known to Occur in Brazil, Whose Life Cycles are Unknown, and/or Need Further Study

Chloroprocta idioidea (R.-D.)
Chloroprocta fuscanipennis (Macq.) (= *idioidea*?)
Chrysomya albiceps albiceps (Wied.)
Chrysomya megacephala (Fab.)
Cochliomyia hominivorax (Coq.)
Hemilucilia benoisti Seguy
Hemilucilia melusina Dear
Hemilucilia segmentaria (Fab.)
Hemilucilia semidiaphana (Rond.)
Hemilucilia souzalopesi Mello
Hemilucilia townsendi Shan.
Paralucilia adespota Dear
Paralucilia fulvicrura (R.-D.)
Calliphora lopesi Mello
Phaenicia japuhybensis Mello
Phaenicia ochricornis (Walk.)
Phaenicia purpurescens (Walk.)
Kuschelomyia ambrosiana Lopes

react to synthetic attractants and these differences can hamper control efforts.

Pavan is working on two related problems: biological control of C. hominivorax and Dermatobia hominis by chalcidoids (Spalangia and unidentified Encyrtidae); and a vaccine against screwworm larvae. He has had some limited success with the pupal parasites under cage conditions. The rationale in the vaccine research is to develop high antibody titres in test animals after a course of inoculations of larval homogenates. Presumably the antibodies will interfere with normal development of larvae in the wound. There are no results yet. Pavan had limited awareness of the literature and when I returned to Chicago I sent him a key article on this subject from Science (Nogge and Giannetti 1980). Many insects are able to absorb orally administered antibodies. Antibodies to muscles or nerves of the flesh fly, Sarcophaga falculata Pand., when fed to the flies, attach specifically to the tissue that had served as antigen and interfere with the normal function of the tissue. Nogge and Giannetti report that when tsetse flies are fed on human blood, the hemolymph of the flies contains human albumin. If the flies then ingest antibodies to human albumin, they die within a short time.

Dr. Angelo do Prado and his group at the University of Campinas are studying the reproductive biology and natural breeding sources of the three recently introduced Chrysomya species — megacephala, albiceps, and putoria. The flies are spreading rapidly across South America (Imbiriba et al. 1977, Guimarães et al. 1978, Prado and Guimarães 1982, Baumgartner and Greenberg 1984). We have calculated their average dispersal rate at 1.8 km/day, which is enhanced by their hitchhiking habit and synanthropy. This rate will bring them to the United States within a decade, without the drama and public concern preceding the Brazilian bee. In the long run these flies are far more

dangerous.

C. putoria breeds in enormous numbers in the excrement at commercial poultry farms and creates a nuisance and health hazard for miles around. In fact, the Campinas region is the major poultry producing and exporting center of the country. It thus becomes the hub for the dissemination of pathogenic organisms by Chrysomya among poultry, and from poultry to people in Brazil and abroad. In the United States, its counterpart in the poultry environment is Fannia canicularis. If, in all likelihood, C. putoria reaches the United States and becomes established in the southern tier of states, it will probably replace Fannia as it has replaced endemic Cochliomyia macellaria in Peru and Brazil (Baumgartner and Greenberg 1984; Guimarães et al. 1979; Hugo de Souza Lopes, personal communication). Fannia canicularis, although endophilic, is much less communicative than C. putoria because it does not readily alight on food.

Chrysomya putoria and C. megacephala may be even more dangerous than the house fly, particularly under conditions of poor sanitation prevailing throughout Latin America and especially when troops are in the field. Karyotype analysis suggests that Brazilian megacephala originated in the Orient (Azeredo-Espin and Pavan 1983) where it breeds in human feces and is commonly known as the latrine fly. In central and tropical Africa, putoria fills the same niche and is also called the latrine fly (B.H. Laurence, personal communication 1980). Both species are communicative eusynanthropes and are known to transport human pathogens including poliovirus types 1, 2 and 3, Coxsackie virus, Salmonella, Shigella, and the eggs of various tapeworms (Greenberg 1971). Both flies are readily attracted to meat and to bruised fruit. We set out meat bait in a semi-tropical, hemisynanthropic area beyond the mountains fringing Rio de Janeiro. All three species of Chrysomya were

abundant, with megacephala the predominant calliphorid.

In Curitiba, the seasonal breeding dynamics of Chrysomya spp. are being studied in garbage dumps outside the city (de Queiroz, personal communication). Using faulty technique in which flies were kept for 24 h at room temperature before processing, Lima (personal communication) was nevertheless able to isolate enteropathogenic Escherichia coli from pools of C. putoria taken in the same city. Interest in fly-borne disease is especially high as Chrysomya entered the New World in this region.

Dr. Izone F. Corrêa, Director of R & D, Agrochemical Division, Ciba-Geigy in São Paulo, described, but did not divulge details of, certain insecticide formulations that appear to effectively attract and kill flies like Chrysomya.

In South America the synanthropy of Chrysomya flies varies somewhat from region to region, also their attraction to human feces. In central Peru, C. putoria was not attracted to human feces (Baumgartner and Greenberg 1985), but in the state of São Paulo it was (Linhares 1981, Ferreira 1983).

Similar issues with medical implications exist in Africa where the status of C. chloropyga chloropyga and C. chloropyga putoria is unresolved. Zumpt (1972) compared male genitalia of both types and found them to be identical, and concluded that the latter is only a subspecies of the former. van Emden (1953) also found the genitalia identical but considered them distinct species on the basis of their distribution and distinctive color patterns. Paterson (1977) found low interfertility and differences in the male genitalia (cerci, harpes and 5th sternite), clothing hairs, and length of the dorso-central setae. He pointed out that chloropyga is typically a carcass breeder, and also an important sheep blow fly. On the other hand, C. putoria is a major domestic pest in much of tropical Africa because of its habit of breeding in privies. This habit, according to Paterson, has never been found in

chloropyga populations; Laurence concurs (personal communication 1980). Ullerich (1976) and Boyes and Shewell (1975) consider the two types distinct species cytologically. Azeredo-Espin and Pavan (1983) conclude from karyotype studies that specimens from the states of Minas Gerais and São Paulo are typical chloropyga, yet, as we already noted, their attraction to human feces is typical putoria. On the other hand, the Peruvian population, in its aversion for human feces, behaves like typical chloropyga. If these differences are real, they suggest separate introductions of the two types into Brazil. Whatever the taxonomic outcome, one important conclusion emerges: regional behavioral differences significantly affect the vector potential of calliphorids; therefore, knowledge of these differences is essential if health services support is to be implemented effectively.

This applies equally to Musca domestica and other eusynanthropic flies. It is noteworthy that M. domestica in the northeastern states of Paraíba and Rio Grande do Norte (Moçoro) lands on face and body, even at night, and acts more like the eye fly, Musca sorbens (Nelson Papavero and Dalton Amorim, personal communication). This behavior is atypical and suggests a role as a vector of eye diseases, not usually associated with the house fly. Such studies have not been undertaken. Carvalho et al. (1984) report important differences in the attraction to various baits among populations of M. domestica and other synanthropic flies in Curitiba, Campinas, and Rio de Janeiro. The classic example are the epidemiologic differences between the behavior of the northern and southern subspecies of M. domestica in the Palearctic region. In the Leningrad area, house flies generally do not breed in latrines, preferring garbage and animal manure. Because they infrequently come in contact with human feces, they are less likely to carry human pathogens. On the Crimean coast, by contrast, the southern house fly,

M. domestica vicina, is the major type visiting privies. This fly crawls over feces and feeds with voracity upon blood and mucous (Shura-Bura 1951 in Greenberg 1973).

These population differences probably apply as well to a consideration of the myiasis producers C. hominivorax, Chrysomya albiceps, and Dermatobia hominis. The latter is a serious pest of people living and working outdoors in the savannahs of Goiás and Mato Grosso, and in the Amazon. A comprehensive treatment of neotropical myiasis is given by Guimarães et al. (1983) (unfortunately in Portuguese) in which a number of other species and families is mentioned and diagnostic drawings, photographs, and keys are included.

Brazil's most recent fly problem is the horn fly, Haematobia irritans. It was introduced into the United States from Europe about a century ago and crossed the country from the east coast to Hawaii in ten years. In the late 30's it turned up in Venezuela but was not reported in neighboring Brazil until the last few years when connecting roads were built. Now that it is in the Amazon, large cattle growers are anxious to contain it, but given the rarity of applied entomologists and government inertia, the fly will probably be all over Brazil by 1990.

Brazilians view their country as actually five countries, defined both geographically and ethnically. For example, the state of Amazonas contains earth's greatest tropical rain forest and is peopled more than 80% by Indians. In the southern part are the states of São Paulo, Santa Catarina, and Rio Grande do Sul, with a European population and outlook. Seeing these differences firsthand makes it clear that climate, culture, and flies significantly impact patterns of enteric disease prevalence and modes of transmission (Victoria et al. 1985). This is perhaps best illustrated by the following example.

Manaus, a city of 800,000, is strategically situated at the confluence of two great rivers, the Solimões and Rio Negro, which form the Amazon river. The city is the conduit for major economic developments in the Amazon region including forestry, cattle ranching, gold mining, and hydroelectric power development. The influx of Indians and the change in lifestyle from low density jungle life to a high density urban existence — typically without sanitary facilities — has created high morbidity environments for diarrheal and other enteric diseases. Flies are numerous but the species have not been inventoried, nor have their vector biology and potential been studied. Isolations of Salmonella types have been made from sylvatic rodents, marsupials, edentates, primates, and lizards (Lins 1970, 1971) and suggest a widespread prevalence of these human pathogens in the wild. Flies should be studied in the urban environment and among those living and working in the midst of the zoonotic cycles in the jungle.

CONCLUSIONS

Our purpose was to determine the feasibility of a full-scale scientific study of the medical biology of synanthropic flies in Brazil. Personnel and facilities in eleven medical entomology laboratories in various regions of the country were evaluated and fly collections were studied. In Brazil, synanthropic flies are abundant and active the year around as potential vectors of enteric pathogens and agents of myiasis. Conditions exist for explosive outbreaks of flies were sanitation to break down and human excrement and garbage to accumulate. Enteric disease epidemics could occur with serious consequences to military operations.

There are about 22 known species of calliphorids. The habits,

distribution, and life cycles of the majority of these flies are largely unknown. This information is needed to (1) identify potentially important vectors; (2) determine in which places and under what conditions each species is likely to become a problem; (3) learn what measures need to be taken to avoid fly build-up; and (4) implement an effective control strategy in the event fly build-up does occur.

A full-scale study of the medical biology of Brazilian calliphorids, the house fly, and other synanthropic flies is feasible and strongly recommended. Five factors support this recommendation and make this mission realistic and of practical importance to the medical support of the military: (1) prevalence of enteric disease throughout the country; (2) abundance of synanthropic flies the year around; (3) absence of vital information on this medically important group of flies; (4) existence of suitable research facilities; and (5) enthusiasm for the project by Brazilian medical entomologists.

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